

Transplanting Retinal Cells Using Bucky Paper for Support

Bucky paper supports the cells before, during, and after surgery.

Ames Research Center, Moffett Field, California

A novel treatment for retinal degenerative disorders involving transplantation of cells into the eye is currently under development at NASA Ames Research Center and Stanford University School of Medicine. The technique uses bucky paper as a support material for retinal pigment epithelial (RPE) cells, iris pigment epithelial (IPE) cells, and/or stem cells. This technology is envisioned as a treatment for age-related macular degeneration, which is the leading cause of blindness in persons over age 65 in Western nations. Additionally, patients with other retinal degenerative disorders, such as retinitis pigmentosa, may be treated by this strategy.

Bucky paper is a mesh of carbon nanotubes (CNTs), as shown in Figure 1, that can be made from any of the commercial sources of CNTs. Bucky paper is biocompatible and capable of supporting the growth of biological cells. Because bucky paper is highly porous, nutrients, oxygen, carbon dioxide, and waste can readily diffuse through it. The thickness, density, and porosity of bucky paper can be tailored in manufacturing. For transplantation of cells into the retina, bucky paper serves simultaneously as a substrate for cell growth and as a barrier for new blood vessel formation, which can be a problem in the exudative type of macular degeneration.

Bucky paper is easily handled during surgical implantation into the eye. Through appropriate choice of manufacturing processes, bucky paper can

be made relatively rigid yet able to conform to the retina when the bucky paper is implanted. Bucky paper offers a distinct advantage over other materials that have been investigated for retinal cell transplantation — lens capsule and Descemet's membrane — which are difficult to handle during

surgery because they are flimsy and do not stay flat.

In preparation for implantation, the selected cells are first cultured onto a piece of bucky paper. A retinotomy is then performed, the cell-covered bucky paper is implanted, and the retina is reattached. Because bucky paper does

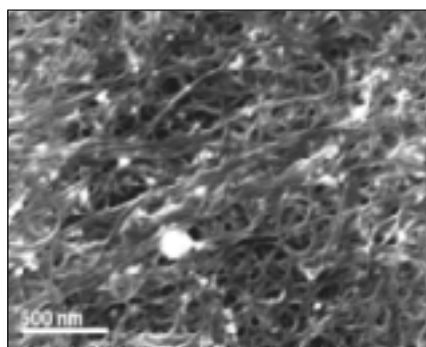


Figure 1. The Mesh of Carbon Nanotubes in Bucky Paper can be seen in this high magnification scanning electron micrograph.

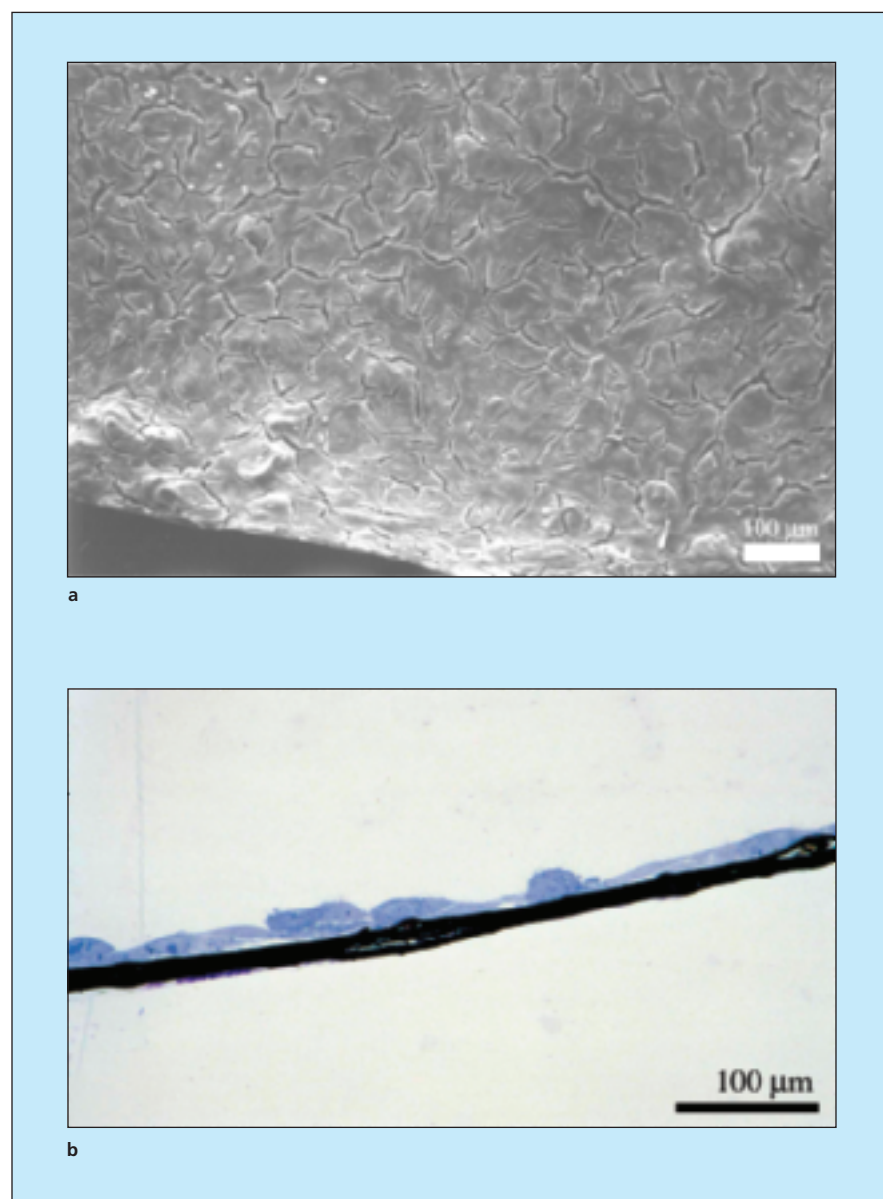


Figure 2. Micrographs of RPE Cells illustrate the following: (a) human RPE cells cultured on bucky paper, as shown in this scanning electron micrograph, form a monolayer which is suitable for transplantation into the retina and (b) light micrograph of human RPE cells (stained blue) cultured on bucky paper (black) viewed in cross section.

not trigger an inflammatory reaction in the eye, it can be left in place after transplantation to serve as a basement membrane patch.

The attachment of RPE (see Figure 2), IPE, and/or stem cells onto the bucky paper may be enhanced by chemically modifying or coating the bucky paper with one or more biologically active substances. The ability to easily

make these modifications may serve as an important way of optimizing retinal cell transplantation for macular degeneration and retinitis pigmentosa and may facilitate other ophthalmologic applications as well.

This patent pending work was performed by David J. Loftus, Martin Cinke, and Meyya Meyyappan of Ames Research Center, Center for Nanotechnology, and by Har-

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Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14940.

Using an Ultrasonic Instrument to Size Extravascular Bubbles

Measurements could be used to guide prebreathing of oxygen to reduce the risk of decompression sickness.

Lyndon B. Johnson Space Center, Houston, Texas

In an ongoing development project, microscopic bubbles in extravascular tissue in a human body will be detected by use of an enhanced version of the apparatus described in "Ultrasonic Bubble-Sizing Instrument" (MSC-22980), *NASA Tech Briefs*, Vol. 24, No. 10 (October 2000), page 62. To recapitulate: The physical basis of the instrument is the use of ultrasound to excite and measure the resonant behavior (oscillatory expansion and contraction) of bubbles. The resonant behavior is a function of the bubble diameter; the instrument exploits the diameter dependence of the resonance frequency and the general nonlinearity of the ultrasonic response of bubbles to detect bubbles and potentially measure their diameters.

In the cited prior article, the application given most prominent mention was the measurement of gaseous emboli (es-

entially, gas bubbles in blood vessels) that cause decompression sickness and complications associated with cardiopulmonary surgery. According to the present proposal, the instrument capabilities would be extended to measure extravascular bubbles with diameters in the approximate range of 1 to 30 μm .

The proposed use of the instrument could contribute further to the understanding and prevention of decompression sickness: There is evidence that suggests that prebreathing oxygen greatly reduces the risk of decompression sickness by reducing the number of microscopic extravascular bubbles. By using the ultrasonic bubble-sizing instrument to detect and/or measure the sizes of such bubbles, it might be possible to predict the risk of decompression sickness. The instrument also has potential as a tool to guide the oxygen-prebreathing

schedules of astronauts; high-altitude aviators; individuals who undertake high-altitude, low-opening (HALO) parachute jumps; and others at risk of decompression sickness. For example, an individual at serious risk of decompression sickness because of high concentrations of extravascular microscopic bubbles could be given a warning to continue to prebreathe oxygen until it was safe to decompress.

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